magnetic force when the sun is south than when he is north of the equator.

The author concludes this section of his investigations by drawing the attention of the Royal Society to this concurrent evidence, from the observations of three observatories situated in parts of the globe so distant from each other, of a semiannual inequality having such strong features of resemblance in both hemispheres, and remarks that it seems difficult to assign such effects to any other than to a cosmical cause. The "inequalities" may in themselves seem to be small; but judged of *scientifically, i. e.* in the proportions they bear to their respective probable errors, they are large.

IV. "Experiments, made at Watford, on the Vibrations occasioned by Railway Trains passing through a Tunnel." By Sir James South, LL.D., F.R.S., Member of the Board of Visitors of the Royal Observatory, Greenwich. Received June 17, 1863.

(Abstract.)

These experiments were made in consequence of an attempt in 1846 to run a line of railway through Greenwich Park, in what seemed to several competent judges a dangerous proximity to the Royal Observatory.

It was abandoned, but (as Sir James South was informed) only for a time; and he thought it right to make some examination of the probable effects of such a vicinity, especially as to the power of a tunnel in deadening the vibrations.

The Watford tunnel was chosen as the observing station, being, on the high authority of the late Mr. Warburton, in ground very analogous to that on which the Royal Observatory stands; and every facility for making observations was afforded by the late Earl of Essex, through whose park and preserves this tunnel passes.

As the chief inconvenience to be feared from the proposed railway was the disturbance of the observations by reflexion in mercury, it seemed best to take a series of these under circumstances as nearly as possible resembling those which might be expected at Greenwich. An Observatory was therefore erected, in which a large and powerful

transit-instrument was mounted, with all the attention to stability that could be given in a first-class Observatory; and it had sufficient azimuthal motion to enable the observer to follow the Pole-star in its whole course; so that night or day (if clear), he could have the reflected image of the star in the mercurial vessel, ready to testify against the tremors caused by any train.

The distance of the vessel from the nearest part of the tunnel was 302 yards, that proposed for Greenwich being 286 yards. The length of the tunnel is 1812 yards; its southern or London end is 643 yards from where the mercury was placed, its northern or Tring end 1281 yards; and about 64 feet of chalk and gravel lie above the brickwork of its crown. The author's preparations were not complete till December 1846, and then a continuance of cloudy weather interfered with observation till January the 11th, 1847, when and on the following nights he obtained results so decisive that he felt it his duty to communicate them at once to the *then* First Lord of the Admiralty, the late Lord Auckland, who was so satisfied with them, that in a letter to Sir James, dated "Admiralty, Jan. 26, 1847," he recorded the impression they had made on his mind in the following words:—"*They would be quite conclusive if the question of carrying a tunnel through Greenwich Park were again to be agitated.*" Sir James, however, continued the work to the end of March.

With the ordinary disturbance to which an Observatory is liable (as wind, carriages, or persons moving near it), the reflected image of a star breaks up into a line of stars, perpendicular to the longest side of the mercury-vessel. With increased agitation, another line of stars perpendicular to the first appears, making a cross. With still more the cross becomes a series of parallel lines of stars; still more makes the images oscillate; and at last all becomes a confused mass of nebulous light. The first of these (the line) is not injurious to onec lass of observations; but the others are, and therefore the second (the cross) was taken as a measure of the beginning and end of injurious disturbance. Signal shots were fired when a train passed the southern entrance of the tunnel, and a shaft 1162 yards from it. Hence the train's velocity was obtained, and thence its position at any given time.

Upwards of 230 observations are given in detail, and their most important results are shown in a Table, which contains the date, the

distances at which the cross of stars begins and ceases to be visible, those at which the series of parallel lines is seen, the velocity in miles per hour, the weight of each engine, and also the length and weight of each train (when it could be identified).

This Table proves that *in all cases* but one (which in fact is scarcely an exception) there is sufficient vibration to excite the cross at 670 yards, and that in 24 per cent. of the number it is seen beyond 1000, its maximum being 1176. At the southern end such distances reach far beyond the tunnel, while at the north they fall within it. From comparing them in the two cases, the author infers that the train's agitation extends laterally as far when it is in the tunnel as when in the open cutting. The amount of disturbance does not depend solely on the velocity and weight of the train, but also on other circumstances, of which prolonged action and length of train are the chief. In one instance, with only a velocity of 11·4 miles, the cross was seen at 1110 yards—a proof that no regulation of the speed in passing an Observatory at a distance of 300 or 400 yards would be of any avail.

The system of parallel lines is only seen between lines making angles of 45° with the perpendicular to the rails, that is, at distances under 427 yards; it scarcely ever is produced unless the cross be visible beyond 1000 yards.

These forms are also produced by the reports of cannon of twelve ounces calibre, at distances from 300 to 3000 yards; in the last case there is but a faint trace of the cross. In all, the appearance is momentary, not lasting in any case more than a second and a half. They are not produced by the roar of a two-pound rocket fired 82 feet from the mercury, though very loud. When the cannon were fired *in the tunnel*, where the perpendicular meets it, *two* sets of tremors were seen—one, he believes, propagated through the ground, the other through the air about a second later, the sound escaping probably through the shafts. Attempts were made to substantiate or refute this hypothesis; but the difficulties of *rapidly* shifting and unshifting the coverings prepared for the purpose were such as to compel him to relinquish them.

These observations were reduced in 1847; but conceiving all danger to the Royal Observatory was past, the author did not think it necessary then to proceed with them. As, however, no Observatory

can now be considered secure from railway injury, he wishes to make them public, in hopes that they may be useful, not only to practical astronomy, but to some other departments of science.

V. "Preliminary Notice of an Examination of *Rubia munjista*, the East-Indian Madder, or Munjeet of Commerce." By JOHN STENHOUSE, LL.D., F.R.S. Received June 18, 1863.

It is rather remarkable that while few vegetable substances have been so frequently and carefully examined by some of the most eminent chemists than the root of the *Rubia tinctorum*, or ordinary madder, the *Rubia munjista*, or munjeet, which is so extensively cultivated in India and employed as a dye-stuff, has been, comparatively speaking, very much overlooked, never having been subjected, apparently, to anything but a very cursory examination. Professor Runge, at the close of his very elaborate memoir upon madder, published in 1835, details a few experiments which he made upon the tinctorial power of munjeet, the constituents of which he regarded as very similar to those of ordinary madder. Professor Runge stated that munjeet contains twice as much available colouring matter as the best Avignon madder. This result was so unexpected that the Prussian Society for the Encouragement of Manufactures, to whom Professor Runge's memoir was originally addressed, referred the matter to three eminent German dyers, Messrs. Dannenberger, Böhm, and Nobiling. These gentlemen reported, as the result of numerous carefully conducted experiments, that, so far from munjeet being richer in colouring matter than ordinary madder, it contained only half the quantity. This conclusion has been abundantly confirmed by the experience of my friend Mr. John Thom, of Birkacre, near Chorley, one of the most skilful of the Lancashire printers. From some incidental notices of munjeet in Persoz and similar writers, and a few experiments which I made some years ago, I was led to suspect that the colouring matters in munjeet, though similar, are by no means identical with those of ordinary madder, and that probably the alizarine or purpurine of madder would be found to be replaced by some corresponding colouring principle. This hypothesis I have found to be essentially correct; for the colouring matter of munjeet, instead of consisting of a mixture of alizarine and purpurine, contains